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(54) EXTRUSION OF GYPSUM PRODUCTS

(71) We, BPB INDUSTRIES LIMITED, a British company of Ferguson House, Marylebone Road, London, N.W.1., do hereby declare the invention, for which we pray that a patent be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the extrusion of compositions containing calcined gypsum and to products produced by this means.

The production of extruded products by the extrusion of aqueous slurries of calcined gypsum has already been attempted but is attended by the difficulty that the unset, freshly extruded material tends to slump and thereby departs from the desired cross section. This difficulty has in the past been met by mixing the calcined gypsum with the minimum of water necessary for extrusion, and consolidating the mix before it is extruded. It has of course been necessary to ensure that the plaster mix does not set until after it has been extruded, for example by using a setting retarder.

The extrusion of a consolidated mix with minimum water itself involves difficulties in the extrusion operation, and has the further limitation that only products of high density can be produced.

The present invention rests on the observation that, when gypsum plaster is mixed with water, the stiffness of the mix increases only slowly at first, but at a later stage the stiffening of the mix advances rapidly until the mix sets completely. It has now been found that a mix of gypsum plaster and water can be extruded to a stable cross section if the rate of setting is so controlled in relation to the time between the initial contact of plaster with water and the moment of extrusion that the mix at extrusion attains a degree of stiffening such that the extruded material has sufficient strength to maintain its extruded cross-section. In this way, it is found that the tendency of the product to slump after extrusion can be avoided without undue consolidation of the mix, and products of predetermined form can be extruded without being confined to the very high densities hitherto thought inevitable.

In a preferred modification of the invention, a synthetic resin is incorporated in the mix, preferably a resin which forms an aqueous solution or dispersion stable under the temperature and pressure conditions obtaining in the extrusion operation. The synthetic resin serves the dual purpose of facilitating extrusion of the mix and enhancing the hardness of the set product. During extrusion, the resin plays an important part by serving as a lubricant and modifying the viscosity of the mix. It is especially valuable in the production of lower density extrusions, because its lubricant function permits the use of a lower extrusion pressure, so helping to keep down the density of the product. Its reinforcing action is also of especial value in the case of lower density products.

The use of resins in the mixes extruded in accordance with the invention is further facilitated because the stiff condition of the plaster mix after extrusion avoids difficulties which would otherwise arise from dimensional instability of the resin during drying. The stiffened plaster serves as a pre-structuring material and forms a matrix within which the resin can harden without deformation of the product. This is particularly important in the case of urea-formaldehyde resins, the hardening of which is often accompanied by a high degree of contraction.

Apart from urea-formaldehyde, examples of other resins which can be used for the purposes of the present invention include melamine-formaldehyde, polyvinyl acetate and polyacrylates. A particularly valuable range of resins for the present purpose is that of copolymers of monomers which include the residue of a synthetic, predominantly tertiary, carboxylic acid made by reaction of olefins with carbon monoxide and water in the presence of an acid catalyst, with other monomers, for example vinyl acetate. Such acids are commercially available under the trade name "Versatic" (Shell Chemical Co. Ltd). The

preferred amount of resin (as solids) is from 2½ to 10% by weight of the plaster.

The density of the extruded products according to the invention can be varied to a considerable extent by varying the amount of water employed in the mix. The higher the water content the lower the resulting density. The preferred amounts of water range from 20% by weight of plaster for relatively dense products to 100% for lower density extrusions.

In the production of lower density products, made possible because the extruded mix no longer relies on minimum water, consolidation or high density to retain its shape after extrusion, additional measures may be taken to reduce the density of the extruded material. According to one preferred procedure, the mix is aerated before extrusion. Aeration of the mix increases its strength: weight ratio, and the smaller the cells achieved by aeration the greater the increase in this ratio.

According to another preferred procedure a lightweight aggregate, such as perlite, vermiculite, or granular polystyrene or urea-formaldehyde foam, is included in the mix. Where the extrusion pressure is low, these aggregates fulfil the function of reducing the bulk density of the set product. Such aggregates, however, and especially vermiculite, can also be included in mixes for extrusion at higher pressures to give denser products. Under the higher pressures, the expanded particles collapse, and this together with the low friction between layers of the collapsed particles provides a further lubricant action in the mix at extrusion. Lightweight aggregate is preferably added in an amount not exceeding 20% by weight of the plaster.

It is also possible to incorporate fibrous reinforcing material such as chopped textile fibres, wood pulp, polypropylene and mineral fibres, and more especially glass fibre, and also conventional aggregates such as sand.

Modifying agents, such as cellulose ethers, which affect the water requirement of the mix can also be added.

It has also been found advantageous especially when extruding products of high density, to include in the mix a minor proportion of clay, such as bentonite. With lower density products there is less to be gained from the presence of clay, and where the plaster is prepared from rock having a sufficiently high clay content a separate addition of clay may be omitted. The preferred magnitude of a clay content in the mix is from 5 to 35% by weight of the plaster.

The plaster itself may be prepared by conventional processes, including batch calcination in so-called kettles. Plaster produced by continuous calcination of ground gypsum in a bed maintained in a fluid condition by the water vapour evolved by calcination, as described in our Patent No. 1,018,464, is also well suited to the present process. The rate of stiffenening and setting of the mix can be adjusted as desired by retarders, accelerators and setting stabilizers already familiar in plaster technology.

The following are examples of the process according to the invention.

Example I

A mix is prepared from the following materials:

	Parts by weight
Gypsum plaster to B.S. 1191 containing not less than 5% clay	67.8
Vermiculite (No. 2 Grade)	6.8
Bentonite, 5% aqueous suspension	0.8
Copolymer of vinyl acetate with a 'Versatic' acid, (Veo Va 10) and fumarate comonomer in the range of 17—25% of total polymer content, aqueous emulsion with 55% total solids (polimul DS 4661)	4.1
Water	20.5
Additive to adjust set	as required

The ingredients of the mix are introduced in the stated proportions into a continuous mixer and on emerging from the mixer are fed into the barrel of an extruder having an extrusion head with a die opening of the required cross section. The rate of setting of the mix is adjusted by addition of retarder or accelerator, and if desired of stabilizer, in relation to the speed of operation of the individual equipment employed, and in particular to the time taken for a given portion of plaster to pass from the point of initial wetting to the extrusion head, in such a manner that the mix has immediately after extrusion sufficient stiffness to maintain its desired cross section, for example on a belt conveyor which may be arranged to transfer the extruded material from the extruder to a drying chamber.

The extruded product of this example dries to give a relatively dense and extremely hard material.

Example II

The following are the ingredients of a mix which can be processed in the manner described in Example I to give a similar product.

	Parts by weight
Gypsum plaster (as Example I)	66.5
Vermiculite	6.7
Polimul DS 4461	5.4
Water	21.4
Additive to adjust set	as required

Example III

The following are the ingredients of a mix

which can be processed as described in Example I, and give a similar product.

	Parts by weight
Gypsum plaster (as Example I)	74.6
Polimul DS 4661	5.1
Water	20.3
Additive to adjust set	as required

Products of lower density can be prepared from the mixes set forth in these Examples if the mixes are modified by increasing the quantity of water up to a proportion of 100% by weight of the plaster, and making any adjustment of the rate of setting found necessary once again to achieve adequate stiffness immediately after extrusion.

WHAT WE CLAIM IS:—

1. A method of producing extruded gypsum products which comprises preparing a mix including gypsum plaster and water, allowing the mix to set until it attains a degree of stiffening which enables it to retain an extruded cross-section, and thereupon extruding the mix to the desired cross section, the mix being adjusted to set at a controlled rate during the period following the initial contact of the plaster with the water so that the mix develops the said degree of stiffening in a predetermined time.

2. A method according to claim 1 in which a synthetic resin is incorporated in the mix.

3. A method according to claim 1 in which the mix contains from 20 to 100% water based on the weight of plaster.

4. A method according to claim 2 in which the synthetic resin is in the form of an aqueous solution or dispersion and is present in an amount of 2½ to 10% resin solids by weight of the plaster.

5. A method according to claim 4 in which the resin is a copolymer of vinyl acetate and the vinyl ester of a synthetic predominantly tertiary carboxylic acid.

6. A method according to claim 1, 2 or 3 in which the mix also contains lightweight aggregate in an amount up to 20% by weight of the plaster.

7. A method according to claim 1, 2 or 3 in which the mix also contains vermiculite in an amount up to 20% of the weight of plaster.

8. A method according to claim 1, 2 or 3 in which the mix also contains clay in an amount from 5 to 35% of the weight of plaster.

9. A method according to claim 1, 2 or 3 in which the mix also contains bentonite in an amount from 5 to 35% of the weight of plaster.

10. A method according to claim 1, 2 or 3 in which the mix is aerated before extrusion.

11. A method of producing extruded gypsum products substantially as described in any of the Examples herein.

12. Extruded gypsum products produced by a method according to any of the preceding claims.

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